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LABORATORY TEST RESULTS OF ROCK CORES FROM NO. 26 COLLIERY, SYDNEY COALFIELD

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by

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ABSTRACT

Preliminary testing of rock core has been completed by the Rock Mechanics Laboratory and the results are contained herein. This data will aid the Cape Breton Coal Research Laboratory in assessing the characteristics of rocks of No. 26 Colliery.

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RÉSULTATS D'ESSAIS DE LABORATOIRE SUR DES NOYAUX ROCHEUX DE LA HOUILLÈRE N° 26, CHAMP HOUILLER DE SYDNEY

par

B. Gorski*

RÉSUMÉ

Les premiers essais sur des noyaux rocheux ont été effectués par le Laboratoire de la mécanique des roches et les résultats sont présentés ici. Ces données aideront le Laboratoire de recherche sur le charbon de Cap-Breton à évaluer les caractéristiques de la houillère n° 26.

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INTRODUCTION

The sandstone and siltstone rock cores received at MRL were tested in accordance with a request from Peter Cain of the Coal Research Laboratory, Sydney, Nova Scotia, in February 1984. The results of the tests, contained in this report, will aid the Coal Research Laboratory in assessing in situ mechanical rock properties at No. 26 Colliery. The laboratory tests undertaken in this program comprised the following:

1. Two uniaxial compressive strength tests, including determinations of Young's modulus.
2. Two triaxial compressive strength tests.
3. Two mercury porosimeter tests.
4. Two constant head water permeability tests.
5. One transient pulse water permeability test.

EXPERIMENTAL PROCEDURES

UNIAXIAL COMPRESSIVE TESTS

The ends of samples of BX core, selected for uniaxial tests were lapped and ground to within specified tolerances and with length to diameter ratios of 2:1. SR-4 strain gauges were then applied. The samples were tested using a 1300 kN capacity Tinius Olsen press. Stress and strain measurements were obtained using two B&K type 1526 indicators and a Moseley X, Y_1, Y_2 recorder. The sample preparation methods and testing procedures used have been described by B. Gorski [1] and M. Gyenge and G. Herget [2].

TRIAXIAL COMPRESSIVE TESTS

Samples selected for triaxial testing were prepared in the same way as described previously. Confining pressure was applied in a 'NX' Hoek cell, by using silicone oil for confinement fluid. 'BX' size samples were accommodated in the Hoek cell by using spacer jackets. As above, the testing equipment and procedure used were described by B. Gorski [1] and M. Gyenge and G. Herget [2].

MERCURY POROSIMETER TESTS

Samples selected for mercury porosity tests were cored to 2.50 cm diameters. The end surfaces were cut at right angles. The specimens were then mercury-intruded at pressures ranging from 1×10^{-3} MPa to 103 MPa, with pressure versus count readings recorded at selected pressures. A mercury porosimeter, Model 910 series manufactured by Micromeritics Corporation, was used for the tests. Details of the testing procedure have been described by B. Gorski and A. Mears [3].

CONSTANT HEAD WATER PERMEABILITY TESTS

A medium-pressure water permeability and confinement pressure apparatus, designed and constructed by the author, was used to conduct two of these tests. A 5000 psi rated, commercially-available, pressure vessel was used to confine the specimen. Sample jacketing, sealing, evacuation and saturation methods are identical to those described by A. Annor et al. [6]. The length to diameter ratio for specimens was 1:1. Details of the testing procedure have been described by B. Gorski [4].

TRANSIENT PULSE WATER PERMEABILITY TEST

The permeability unit used for this test was manufactured by Pressure Systems Research, Alamo, California. The steady state transient pulse technique developed by Brace et al. [5] was used for the permeability measurements. Sample preparation, equipment description and the test procedure have been described by A. Annor et al. [6].

RESULTS

The results contained hereunder relate only to the specific samples tested and are not to be used for design purposes.

SAMPLE DENSITIES

Table 1 lists the dimensions and dry densities of the samples tested.

Table 1 - Sample dry densities

Sample type	Location	Test type	Length (cm)	Diameter (cm)	Density (g/cm^3)
Siltstone	BH5-1	Uniaxial	8.212	4.405	2.7
Sandstone	BH4-2	Uniaxial	8.227	4.255	2.5
Siltstone	BH5-1	Triaxial	8.216	4.510	2.7
Sandstone	BH5-3	Triaxial	8.226	4.416	2.5
Sandstone	BH5-3	Porosity	2.610	2.560	2.5
Siltstone	BH5-1	Porosity	2.300	2.560	2.7
Sandstone	BH4-2	Permeability	4.103	4.308	2.5
Siltstone	BH5-1	Permeability	4.042	4.396	2.7

By comparing the densities listed in Table 1 it can be deduced that the porosity of the sandstone is considerably greater than that of the siltstone.

UNIAXIAL TEST RESULTS

The uniaxial compressive strengths of the siltstone and sandstone samples were calculated to be 82.31 and 85.31 MPa, respectively. Bedding planes approximately 1 mm thick, having high concentrations of muscovite, were found to be preferred planes of weakness in the sandstone samples. One sandstone sample failed along one of these planes of weakness which was orientated 55° to the horizontal. It can be deduced, therefore, that the uniaxial strength stated above for the sandstone is less than that expected for an intact sandstone originating from the same formation. Axial splitting observed in the siltstone sample after testing would indicate the value as stated above to be within strength limits.

Young's modulus for the siltstone and sandstone samples were calculated to be 25.48 and 20.16 GPa, respectively.

TRIAXIAL TEST RESULTS

Table 2 contains the results of the two triaxial tests.

Table 2 - Triaxial test results

Sample	Peak strength (MPa)	Confining pressure (MPa)	Stress difference (MPa)	Peak strain ε%
Siltstone	172.15	24.13	148.02	0.68
Sandstone	284.86	24.13	260.73	1.26

Both samples exhibited single diagonal modes of failure 60° to the horizontal, neither of which followed existing planes of weakness.

MERCURY POROSITY TEST RESULTS

The porosimeter indicates the quantities of non-wetting liquid mercury that is forced under increasing pressure (103 MPa max.) into the pores of a rock specimen. The Washburn equation is used to calculate the diameter of rock pores intruded as follows;

$$D = \frac{-4\ S \cos \theta}{P}$$

D: Pore diameter (Microns)

S: Surface tension of mercury (474 dynes/cm^2 at 25°C)

θ: Contact angle of mercury (130°)

P: Applied pressure

Table 3 contains the results of the two mercury porosimeter tests performed.

Table 3 - Mercury porosimeter results

Sample	Sample volume (cm^3)	Porosity (%)	Pore diameter μ
Sandstone	14.434	4.7	0.08 - 0.35
Siltstone	11.838	less than 0.146%	less than 0.01

CONSTANT HEAD PERMEABILITY TEST RESULTS

Darcy's law is used to calculate the water permeability of the rock specimens as follows;

$$k = \frac{\mu q L}{A (p_1 - p_2)}$$

k: Permeability (Darcies)

μ: Viscosity of water (centipoise)

q: Incompressible liquid volume flow rate (cm^3/sec)

L: Length of core sample (cm)

A: Cross sectional area (cm^2)

p_1-p_2: Pressure difference from inflow to outflow face of sample (atmospheres)

Further to the above the samples were tested in a confined state. This method closely duplicated the insitu overburden pressures of 24 MPa.

Table 4 summarizes the results as follows:

Table 4 - Constant head water permeability test results

Sample	End area (cm^2)	Length (cm)	P_1-P_2 (atm)	Viscosity (μ)	q (cm^3/sec)	K (nanodarcies)
Sandstone	14.576	4.103	102.07	0.9761	0.0001948	500
			119.08	0.9761	0.0002386	500
			136.09	0.9761	0.0002873	500
Siltstone	15.178	4.042	102.07	0.9761	$0.6 \times 10_6$	1.4*
			119.08	0.9761	$0.3 \times 10_6$	0.65*
			136.09	0.9761	$0.4 \times 10_6$	0.76*

* With such low readings it can only be said the permeability is less than that stated. This same sample was subjected to the transient pulse technique permeability test to cross-check the low readings.

TRANSIENT PULSE PERMEABILITY TEST

Actual tests results were not arrived at using this test method. The siltstone rock tested is considered virtually impervious to water intrusion or as having a permeability less than 1 nanodarcy.

DISCUSSION

The limestone and siltstone rock material are classified as strong and elastic prior to failure, and brittle after uniaxial failure [7]. The siltstone is impervious, having negligible porosity, whereas the sandstone is slightly permeable and has appreciable porosity. Reduction of overburden pressure (stress relief) can be seen to increase the permeability of the sandstone.

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